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Plant Wearables and Airdropped Sensors Could Sow Big Data Seeds

Cheaper plant sensors could bring monitoring to individual plants on a massive scale

By **Jeremy Hsu**

Photo: Kaust

Stretchable plant wearables and smart tags dropped by drones aim to help give farming a big data makeover. The relatively cheap technologies for mass monitoring of individual plants across large greenhouses or crop fields could get field tests in three countries starting in 2019.

The idea came from researchers at King Abdullah University of Science and Technology (KAUST), in Saudi Arabia, with expertise in flexible electronics. After talking with colleagues who were cultivating genetically engineered plants in greenhouses, they recognized the need for inexpensive sensors that could be deployed en masse and report on individual plant conditions. Their early offerings include a stretchable sensor for measuring micrometer-level changes in plant growth and a PlantCopter temperature and humidity sensor designed to be dropped from a drone and corkscrew its way through the air for a gradual descent.

"When you are deploying PlantCopters, they get stuck strategically to the leaves of the plants because of the design architecture," says Muhammad Mustafa Hussain, a professor of electrical engineering at KAUST. "Obviously not 100 percent of the PlantCopters will be stuck to plants, but that is fine in the context of their cost."

The vision of Hussain and his colleagues—including Joanna Nassar, lead author on the study and currently a postdoctoral researcher at the California Institute of Technology, in Pasadena—is to bring the Internet of Things to plants through cheap biodegradable materials and low-power Bluetooth wireless communication. Their work was published online in the journal *npj Flexible Electronics* on 10 September 2018.

Many commercial agricultural monitoring systems often taken the form of extensively trained computer-vision camera systems that monitor plant growth, and baton-shaped sensors stuck in the soil to measure conditions such as temperature or humidity. But these are often ill-equipped to monitor the more minute changes in plant and environmental conditions—or else they are too expensive for many farmers to use on a large scale.

"The plant-monitoring systems you can get at Home Depot or Amazon are fairly expensive, and you have to go throughout the field and place them individually without them being able to communicate," Hussain explains. "And when they get smarter with communication, the price goes up."

Both KAUST sensors rely on a low-power system that lasted for an average of 151 days while logging data every two seconds during early lab testing. This system consists of a small rechargeable lithium ion battery and a programmable-system-on-chip with 256 kilobytes of internal flash memory to record and store data. Bluetooth chips enable the sensors to transmit their data either to nearby drones or people with smartphones.

First, the researchers created a plant-wearable sensor—made from polymer and thin gold metal film—that has the flexibility to attach in any position on a plant. They tested this stretchable strain sensor on both barley and lucky bamboo plants during trial periods of several hours or days to show that they could detect even the most minute growth changes.

Gif: KAUST

Second, the team created a 3D-printed temperature and humidity sensor that can be dropped from drones in large numbers. This PlantCopter sensor was inspired by dandelion flower seeds and maple seeds that float through the air like miniature helicopters. It's a design that could ideally allow for widespread dispersion of the sensors with minimal effort, whereas the plant wearable for measuring plant growth would still have to be attached by hand.

An initial demonstration showed that the team could maintain a smartphone Bluetooth connection with the PlantCopter as it was dropped from a height of 50 feet and landed on the ground. But the somewhat bolder vision of the PlantCopter has not yet been tested through a mass airdrop by drone.

Still, the team aims to develop a drone with both sufficient battery life and some autonomous capabilities to perform such duties by April 2019. That time frame coincides with a plan to conduct field trials in three countries: India, Sri Lanka and Zambia.

All this talk of individual plant sensors may seem like small potatoes. But taken together, such sensors or similar solutions could add up to part of a much larger big data revolution sweeping through agriculture. Farmers will need as much fine-grained data as they can get about what's happening on the ground in order to boost productivity through a carefully orchestrated dance of drones, robotic equipment, and smart sensors.

"My overarching objective is to collect big data and infuse it with AI so that drones can make real-time decisions like spreading fertilizer and pesticides as needed," Hussain says. "My vision is if productivity goes up by even 1 percent, I think that would feed more people."

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